Agroecology as a pathway to resilience justice: peasant movements and collective action in the Niayes coastal region of Senegal

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In semi-arid sub-Saharan Africa, farming populations face harsh climatic conditions but also very unequal and dynamic social processes that affect their resilience. This study addresses aspects of power and social justice related with the social-ecological system of the Niayes coastal region of Senegal, and examines the potential of agroecology to improve the adaptive capacity of smallholder farmers. We performed a knowledge co-production process with a local farmer union to identify the main social-ecological nexuses that matter for smallholder farmers, their dynamics and the influence of powerful actors and institutions on them. We also look at the potential actions of the farmer union under the banner of agroecology to transform these dynamics. We found that social-ecological dynamics involve reinforcing feedback loops that undermine the resilience of smallholder farmers and that powerful actors such as agribusinesses have a strong influence on these processes. Union actions promoting agroecology have enhanced system thinking and related solutions, but observed social justice claims are very recent and have a limited scope. Our findings expand the notion of resilience grabbing, understood as the undermining of resilience through the loss of commons, to include systemic degradations due to direct and indirect actions of involved stakeholders. We also propose to expand the notion of resilience justice vertically, integrating procedural and recognition justice, and horizontally, integrating linked social-ecological issues. We conclude that agroecology can become a transformative bridge from resilience grabbing to resilience justice, but must be more sensitive to power relations, in particular around labour.

Keywords: agroecology, environmental justice, social-ecological system, transformation knowledge, resilience grabbing, resilience justice, Niayes, Senegal

Introduction

In arid and semi-arid rural areas of Sub-Saharan Africa, farming populations are particularly vulnerable to shocks and changing conditions such as climate change, droughts and land degradation. Naturally adverse conditions are exacerbated by social, political and economic factors such as pressure on resources, poverty and conflicts (Leichenko, O'Brien 2002; Hope 2009; Ellis 2006). This is also the case for coastal regions, especially the peri-urban ones, which are subject to strong social and ecological dynamics due to high population density, social diversity and the impacts of climate change and other global environmental phenomena (Adger et al. 2005).

For these reasons, understanding processes that hamper these populations to cope with these vulnerabilities and exploring pathways to make them more resilient require a social-ecological approach. The resilience of farming livelihoods in sub-Saharan Africa rests on multiple dimensions including access to assets, self-organization and capacity for learning (Ifejika Speranza et al. 2014). However, little is known on how these dimensions interact, what drives their dynamics and what the farmers' agency to act on them looks like. A particularly relevant but often overlooked aspect is the importance of social diversity and power in conceptualizing social-ecological systems and their resilience (Fabinyi et al. 2014).

This study contributes to fill this gap by addressing power and social justice issues related to social-ecological changes occurring in the coastal peri-urban Niayes region in Senegal. It builds on a close collaboration between researchers and a local farmer union to co-produce knowledge on these social-ecological dynamics, their implications in terms of social justice and the role of the union in trying to transform them. More specifically, we assess the pressures that put at risk the access to key resilience assets for smallholder farmers and their interactions. We further show that these pressures can be traced back to inequitable power relationships and institutions that support them, and thus require considering resilience issues with the lens of social justice. Finally, we examine the transformative potential of agroecology as a focus adopted by the farmers' union to address these pressures.

Packing these different elements together requires conceptual refinements that bring closer notions that have remained disconnected until now. Literature on social-ecological systems mainly focuses on sustainability and resilience as desirable states, implicitly or explicitly. It is only recently that environmental researchers have recognized that sustainability and social justice are deeply intertwined drivers and outcomes of social-ecological dynamics (Sikor 2014; Leach et al. 2018). Despite this, few connections exist between research on resilience and social science that engages with the justices and injustices dimensions of environmental change (Cote, Nightingale 2012). Sustainability, resilience and justice are often framed as trade-offs that should be solved through negotiation (Fabinyi et al. 2014; Leach et al. 2018).

A large body of literature nevertheless provides evidence of processes such as land grabbing (Borras et al. 2011) that affect both resilience and social justice in Global South contexts. These studies however usually focus on a single resource and overlook systemic links and processes. There is, therefore, a need for conceptual innovation to

connect systemic thinking with issues of power and social justice. To do this, we propose to build on and refine the notions of 'resilience grabbing' and 'resilience justice'. Resilience grabbing focuses on the reduction of adaptive capacity of people in social-ecological systems due to the undermining of environmental commons (Haller 2019). Resilience justice focuses on the equitable opportunities of human communities to anticipate the risks and adapt to sudden shocks and changing conditions (Arnold 2018). We further propose to discuss agroecology as a potentially transformative pathway from resilience grabbing to resilience justice.

Our case study area, the Niayes region of Senegal, is located in semi-arid sub-Saharan Africa and is also a very dynamic coastal and peri-urban area with high social and ecological diversity. Smallholder farmers who supply the city of Dakar with vegetables using traditional irrigation methods are facing high resource competition and highly unequal socio-economic processes. The Niayes thus represents a privileged setting to examine power and justice issues in social-ecological dynamics. Furthermore, the region is the first in the country where peasant movements focusing on agreocology have emerged and have implemented this approach for more than 30 years.

Justice in social-ecological research: beyond trade-offs

Social anthropologists and political ecologists have criticized social-ecological approaches for missing key aspects of social diversity and power (Fabinyi *et al.* 2014). This is because the natural science-based notions of social-ecological systems and resilience have developed independently of social sciences that address questions of power related to environmental issues, such as political ecology (Cote, Nightingale 2012). Consequently, most social-ecological literature frames sustainability or resilience as intrinsically good for the environment and the people who depend on it without addressing unequal power relationships within and between social groups. For example, the adoption of resilience in planning, such as making room for flooding water in peri-urban areas, can lead to housing losses without proper compensation for the poorest communities and have thus detrimental effects on the distribution of social and environmental costs and benefits (Fainstein 2015; Bottazzi *et al.* 2019).

Because the study of social-ecological systems and power relationships stems from different disciplinary backgrounds, it has been proposed to treat normative notions associated such as resilience and equity as fundamentally separate notions. Social justice is either seen as an instrumental way of attaining sustainability (or resilience), or as an intrinsic goal to trade-off against sustainability or resilience (Fabinyi et al. 2014). For example, studies have shown that environmental measures and policies perceived as just are more likely to be effective (Brondizio, Tourneau 2016; Oldekop et al. 2016). The idea that justice and resilience are trade-offs is visible in the 2030 UN Agenda, that pledges to 'leave no one behind', and incorporates the reduction of inequalities as one of its goals to balance against others (United Nations 2015), and in the literature on planetary boundaries and safe and just operating spaces (Dearing et al. 2014; Leach et al. 2013).

Nevertheless, empirical insights from both social anthropology and political ecology show that in many contexts, social-ecological degradations take their roots in

social inequalities, lack of transparency or concentration of power. For example, large-scale land acquisitions or extractive industries have often strong impacts on both ecosystems and social well-being (Borras Jr, Franco 2011; Martinez-Alier 2009). Approaches based on political economy such as accumulation by dispossession (Harvey 2004) and 'capitalism in web of life' (Moore 2015) focus on how socio-environmental inequalities are produced. They postulate that global capitalism continuously needs to expand its search for cheaper inputs and workforce, capturing human and non-human energy through socio-economic transformation processes. States often support this transformation by enhancing the commodification of ecosystems and human labour, expelling peasants, suppressing 'commons' and encouraging the extraction of natural resources.

Environmental justice also deals with socio-environmental inequalities. This field started studying the social distribution of environmental impacts, such as pollution and waste disposals in relation to American ethnic minorities (Bullard 1994; Pellow 2004). Environmental justice has more recently addressed the distribution of environmental goods (Anguelovski 2015) and the processes through which environmental inequalities arise, such as uneven participation in decision-making and lack of social and cultural recognition of disadvantaged groups (Schlosberg 2007). There has been an increased convergence between political ecology and environmental justice (Holifield 2015; Svarstad, Benjaminsen 2020), in particular with the expansion of environmental justice approaches to North-South issues and global impacts such as climate change (Schlosberg 2013). These developments call for a reconceptualization of a predominantly urban and impact-based environmental justice towards an understanding that makes dispossession, accumulation and resistance processes visible (Anguelovski, Martínez Alier 2014; Temper et al. 2015).

We sustain that both positions that either treat resilience as systemic processes or as normative and linear, risk overlooking more complex scenarios of social-ecological degradation. There is a need to include direct and intended causes of degradation such as the grab of a critical resource (land, water, labour or biodiversity), but also more indirect or semi-intended processes of social-ecological degradation also called 'diffuse dispossession' (Vorbrugg 2019) such as a lack of urban planning, political inertia or multi-causal effects blurring the exact origin of the problem. As a matter of fact, few studies have engaged in combining systemic links with power and equity perspectives.

Resilience and justice: towards a systemic understanding

Haller's notion of resilience grabbing (Haller 2019) brings social-ecological framings closer to theories of dispossession and captures the reduction of adaptive capacity of people due to the undermining of environmental commons. His approach postulates that although access to common-pool resources is crucial in times of stress and crisis, they are being undermined by several processes at work, including the erosion of local institutions through migration and wage labour and the development of fragmented state control that favours de facto open access regimes or privatization (Haller 2019).

This approach to resilience grabbing offers an interesting perspective to address what matters for rural smallholders in terms of access to resources, assets and resilience from a power and justice perspective. However, while Haller's notion of resilience grabbing mainly focuses on land and its different meanings, it makes little reference to multiple inter-connected threats undermining most vulnerable groups' capacity to adapt, buffer, anticipate or cope with ongoing social-ecological degradations. These include, for example, poor working conditions (e.g. security, incomes, health, social protection), lack of adequate planning and environmental policies, unregulated markets, over-extractive activities, corruption, political co-optation and inertia, and so on. In our view, resilience grabbing can be extended to any voluntary action and inaction that undermine the capacity of vulnerable people to cope with social and ecological threats with a particular interest on the lack of accountability, responsiveness and responsibility of public entities. Though our definition is broader, it does not occult aspects of resilience grabbing focusing on a single resource and the erosion of environmental commons which remains highly relevant too (Haller 2019).

Our approach emphasises the idea that some processes that affect social-ecological smallholder systems cannot be easily identified as 'grabs' but represent diffuse dispossession processes (Vorbrugg 2019). These processes are not necessarily tied to 'evil grabbers' but can involve many different actors with various levels of awareness and agency through intertwined and indirect social-ecological linkages. For this reason, we also sustain that the notion of grabbing needs to be expanded to allow a broader scope of power relevant processes that affect smallholders. We argue that in this sense, investigating 'grabbing' processes must, on the one hand, extend to institutions and structures that allow appropriation and accumulation and, on the other hand, also considering the agency of individuals and communities who are affected by these processes.

These arguments call our attention to the possibility of a resilience justice and its theoretical anchoring. Arnold (2018) has coined the notion of resilience justice to assess policies and programmes such as ecological revitalization and disaster management in terms of social equity; resilience justice is defined as 'the equitable capacity of all human communities to adapt to sudden shocks and changing conditions' (Arnold 2018: 186). Resilience justice is framed as one of the changes needed to make legal systems more adaptive, by making the link between the disparities in communities' vulnerabilities to disasters and unequal adaptive capacities in social, ecological and institutional systems. However, we sustain that resilience justice can also integrate legal aspects through a broader framing on institutions and actors, which would also address justice issues in decision-making processes. This is especially relevant in the Global South where informal institutions play a prominent role besides legal systems.

We therefore, propose to expand the concept of resilience justice both horizontally and vertically. Horizontally, resilience justice connects systemic social-ecological transformations with questions of power. Vertically, resilience justice does not only include the capacities, vulnerabilities and conditions of disadvantaged people, but also puts emphasis on the agency of involved stakeholders. This includes investigating

accumulation and dispossession processes by powerful actors but also the actions taken by the affected social groups and their allies. In this sense, resilience justice becomes a broader framework to look at issues of justice and injustice in social-ecological processes and changes, involving three main dimensions: first, addressing empirically the social-ecological ties that matter for the social groups under focus; second identifying direct and indirect as well as intentional and semi-intentional causalities and their systemic effects and feed-back loops undermining the resilience capacity of these groups; and third, studying how affected people and their allies frame and organize resistance actions (or agency) against these processes.

Agroecology: a transformative potential for resilience justice ?

We further argue that agroecology can bridge system thinking with agency and provide a framing to transform resilience grabbing into resilience justice. Agroecology has evolved from a focus on farming techniques to a social movement defending the rights of small farmers (Wezel et al. 2009; Altieri, Toledo 2011). For these reasons, it represents an excellent topic to study resilience justice as it combines social-ecological transformations with notions of justice and equity. Agroecology also bridges systemic views, social justice orientations and resistance actions through the consideration of broader contexts, such as food systems, in which agricultural production is embedded (Gliessman 2016).

The transformative power of agroecology is illustrated by its ties with Latin American farmer movements who organize to gain access to agroecological knowledge but also land, seeds, government services, ecological restoration and solidarity markers through collective action and increase resilience and sustainability (Altieri, Toledo 2011). Some studies have shown the multiple synergies (and some trade-offs) between diversified agroecological practices and economic outcomes (Rosa-Schleich et al. 2019) suggesting that agroecology has the potential to increase farmers' resilience (Milestad, Darnhofer 2003).

However, though the agroecological movement is well established in some Latin American countries, its transformative potential on the African continent is less known. In sub-Saharan Africa, farmer movements tend to be more recent than in Latin America; they have a stronger dependence on foreign aid and international NGOs and also tend to be co-opted by governments (Hrabanski 2010). This could act as a limiting factor for their emancipation and their transformative potential towards resilience justice. One thus needs to address the transformative power of the agroecological farmer movement critically.

To sum up, our study pursues the following objectives: first, we aim at understanding the social-ecological processes and nexuses that matter for smallholder farmers in the area of study through a participatory process. Second, we investigate how these elements are directly or indirectly related to intentional or semi-intentional appropriation processes linked to actors and institutions. Third, we address the transformative potentialities and limitations of farmer union's actions taken under the banner of agroecology by examining its activities, discourses, strategies and anchoring points on system elements, institutions and actors.

Materials and methods

Study area: the Niayes of Senegal

The Niayes region primarily designates the 5-30 km wide coastal strip located along the Atlantic Ocean Coast between the cities of Dakar and Saint-Louis in Senegal. Despite a low pluviometry (350-450 mm per year), the region is particularity suitable for horticulture due to the marine trade winds that protect the area from warm and dry *harmattan* winds, and due to the presence of shallow groundwater in inter-dune basins (Fare *et al.* 2017). The Niayes region currently supplies 50-65% of fresh vegetables for the country (Ibid.). Our study focuses specifically on the Southern part of the Niayes located in the Thies region that corresponds to the municipalities of Diender and Kayar (Figure 1), which have a total of 28,000 and 20'000 inhabitants, respectively. The agricultural activity in the area concentrates on inter-dune basins called 'Niayes'. Basins located between coastal dunes have sandy soils, and those between older continental dunes have peaty soils that can be waterlogged during the rainy season. Most cultivation in the Niayes occurs during the dry season and is irrigated by pumping the Nappe des Sables Quaternaire (NSQ) groundwater table found at 0-15 m depth in the inter-dune depressions. The NSQ is a primarily renewable water source that depends on local seasonal rainfall.

In pre-colonial times, the area was used for seasonal pasture, palm recollection, and fishing. Shifting agriculture with millet and peanuts started in the 18th Century, and from 1930 to 1960, the French colonial authorities supported horticulture development to supply the growing city of Dakar. The drought of 1970-1980 led to the abandonment of rain-fed cultivation in sandy soils. The long-established families with access to best soils could invest and started to hire 5-6 month seasonal labour (*sourgha*) based on sharecropping (*mbeye seddo*) arrangements. Since the 1990s, increased demand in Dakar and the opening of export markets led to the establishment of agribusinesses (Fare *et al.* 2017) and a growing use of pesticides with little safety and numerous accidents (Hardin 2019). Even more recently, the State has targeted the area for infrastructure development, including the construction of groundwater capitation facilities to supply the city of Dakar with drinking water, the construction of the Dakar-St Louis highway, and oil prospection off Kayar's shore. This very dynamic development coupled with the weak natural resource governance makes the future of horticulture uncertain in the area (Camara *et al.* 2019).

Co-producing knowledge with a farmer union: the FAPD

This study is based on a process of co-production of knowledge that engaged the Federation of Diender Agropastoralists (Fédération des Agropasteurs de Diender FAPD) and Senegalese and Swiss researchers between September 2018 and November 2019. FAPD is the main organization supporting smallholder farmers in the Diender and Kayar municipalities. It has focused on the development of ecological agriculture since the beginning of its activities in 1982. The FAPD currently claims 3000 members in the 24 villages of the two municipalities, who are distributed across five zones: Keur Abdou Ndoye (KAN), Keur Matar Gueye (KMG), Zone Nord, Diender and Daara.

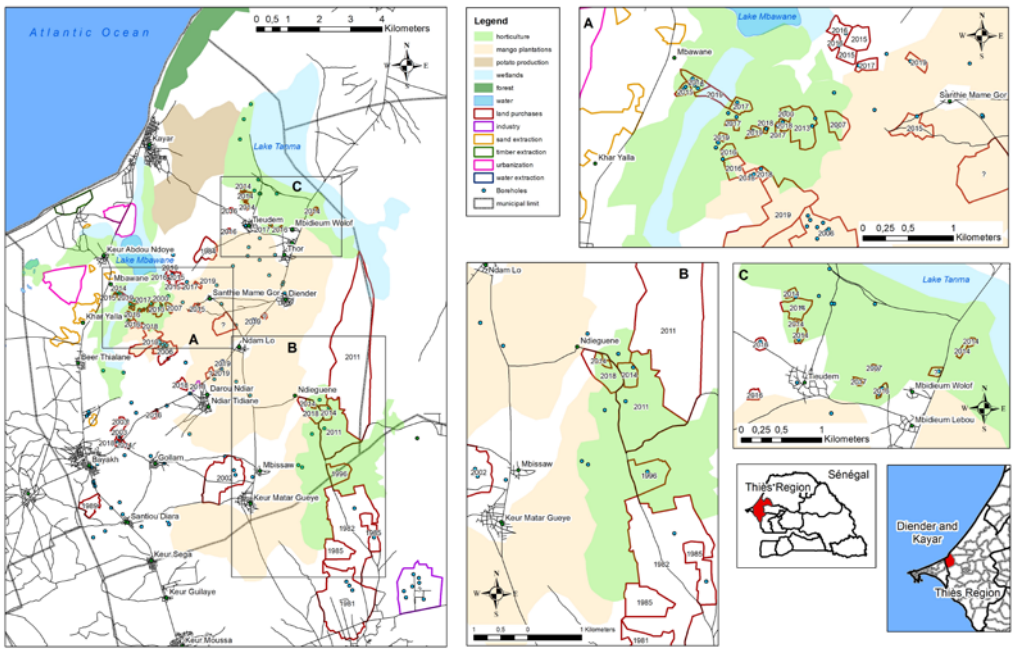


Figure 1. Location and map of the study area, including main land use, land session and boreholes. (a): Keur Abdou Ndoye (KAN) area; (b): Keur Matar Gueye (KMG) area and (c): Zone Nord.

Co-production of knowledge takes place with the establishment of a collaborative endeavour between academic and non-academic actors (Robinson, Tansey 2006; Pohl *et al.* 2010). It takes place in a public space where science and the public interact (Nowotny *et al.* 2001), and from which new non-academic and new academic knowledge emerges (Pohl *et al.* 2010). Co-production of knowledge has been used to enhance the adaptive capacity of communities facing uncertain environmental change through learning feedback processes between researchers and communities (Armitage *et al.* 2011). The enhanced integration of local and external knowledge can also lead to broaden the scope on livelihood assets and provide a more integrative understanding of natural resources and livelihood activities (Jacobi *et al.* 2017). Knowledge co-production processes can also advance the understanding of justice issues through the integration of 'activist knowledge', namely local knowledge on conflictive resource extraction and ecological transformations (Martinez-Alier *et al.* 2011; Anguelovski, Martínez Alier 2014).

We started our study with FAPD leaders in September 2018. The FAPD drew our attention to processes of resource appropriation in the area, which they considered a key barrier for the adoption of organic agriculture and agroecological practices. Figure 2 shows the complete data collection and analysis process. We established a joint research agenda to build a database on pressures including land purchases and boreholes performed close to the production zones of the FAPD farmers. We used a combination of ground information, semi-structured interviews with farmers, Google Earth (Google Inc.) images, and existing data (official database on boreholes, project documents and evaluations and municipal development plans). We discussed these preliminary results at a meeting with the FAPD in October 2019. We then identified six relevant sub-systems for farmer smallholders, namely land, water, labour and livelihoods, agricultural inputs, ecosystems and markets. We created a guide with open questions on these systems and

carried it out at four focus group discussions (FGD), at the FAPD headquarters and in the union zones of Zone Nord, KAN and KMG, with a total of 36 participants (23 men and 13 women) who were among active FAPD members. We asked participants to identify key processes, rules/institutions and actors involved in each sub-system. We also asked them to map the existing pressures on land, water and natural resources on Google Earth (Google Inc.) images printed in A0 format. We ran the FGD in Wolof, we recorded them and took written notes in French after simultaneous translation performed by two bilingual researchers.

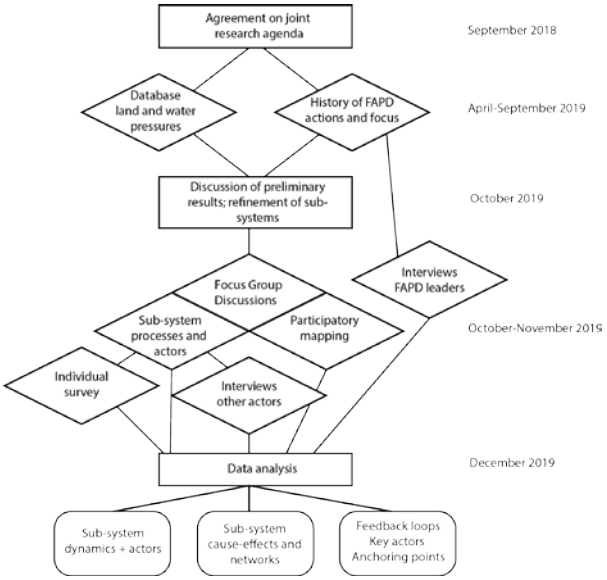


Figure 2. Flow chart of the methodological process of the study.

In parallel, we documented the key actions carried out by FAPD to support smallholders' interests since its creation in 1982, using interviews with founders and former leaders of the organization, the consultation of internal archives and project documents. We finally completed the data with a short survey of FGD participants with farm including land and water use, crops, labour, inputs and commercialization, and with semi-structured interviews with external actors, including larger farmers, fishermen, municipal authorities and local experts. To analyse the data, we matched and complemented the database on pressures with the information from the participatory mapping. We then used the information given at the FGD and complementary interviews to characterize each sub-system in terms of dynamic processes, terms of access for smallholders, prevailing institutions and key actors (suppl. mat. Table 1) and linked these elements to each other via cause-effect chains (suppl. mat. Table 2). To obtain an overview of the social-ecological links, we merged all sub-systems into a network representation, using the network visualization and analysis software Gephi (www.gephi.org) with sub-system dynamics, actors and institutions as nodes and cause-effect relationships as edges. We plotted the network so that edges are more or less of equal length and there are as few crossing edges as possible (Fruchterman, Reingold 1991). This allowed us to visually identify qualitative feedback loops (Justus, 2006; Lewins 1974) between key actors and system dynamics, as well as to identify the focus of the FAPD actions on these dynamics and actors.

Results

This section presents the collected and analysed data in relation to the three objectives of the study. First, FGD participants identified the main social-ecological processes that matter for smallholder farmers in their areas. Figure 1 and Figure 3 provide further evidence of the dynamics for the sub-systems land and water. These processes can also be represented as a network (Figure 4) in which nexuses and feedback loops between the systems are visible. The second section shows the links between these processes and key institutions and actors. Finally, the third section addresses the actions taken by the FAPD and how they connect with processes, institutions and actors.

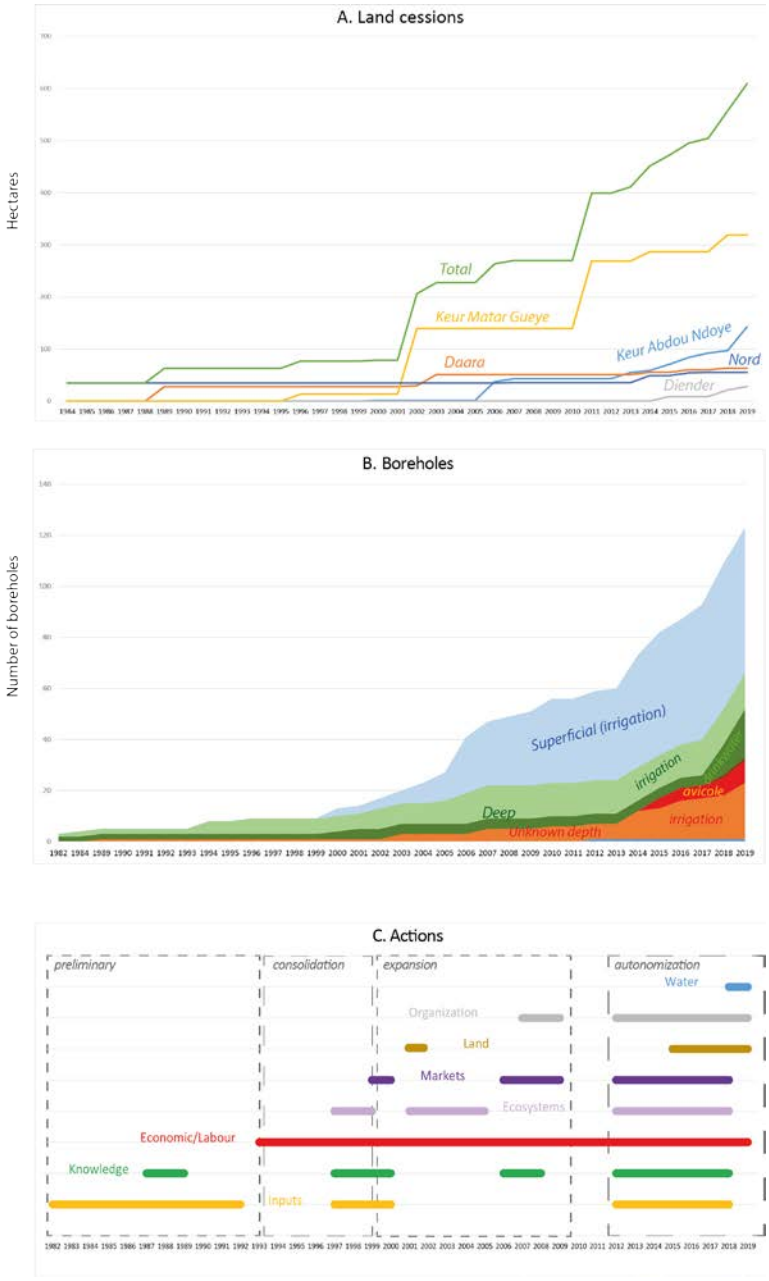
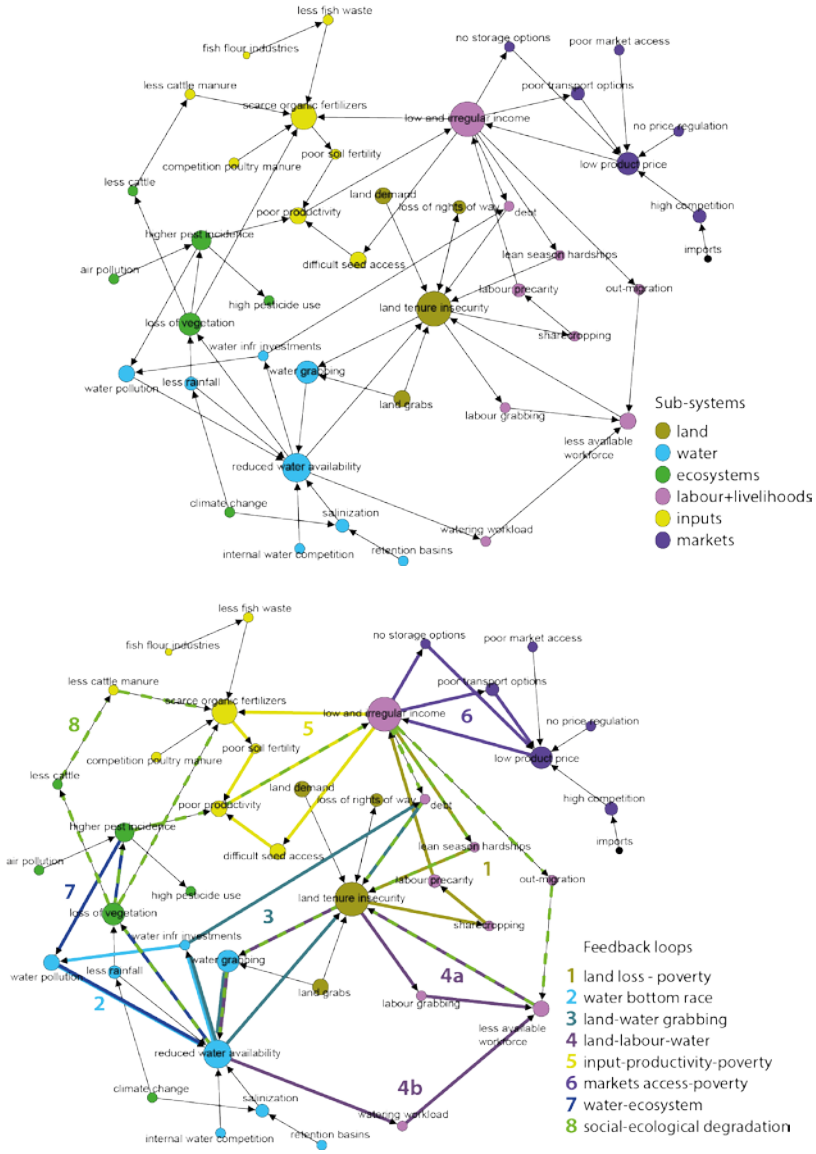


Figure 3. Timeline of land cessions (a), boreholes (b) and FAPD actions by domain of intervention (c).

Social-ecological processes and nexuses

FGD participants mentioned land tenure insecurity and losses as a prominent issue. Most farmers perform horticulture on small to medium plots ranging from 250 to 1000 square meters (Zone Nord; Figure 1C), 1000 square meters to 1,7 hectares (KAN area; Figure 1A), and 5000 square meters to 2 hectares (KMG area, Figure 1B). Rain-fed agriculture on sandy soils has been abandoned since the 1970 droughts. Large land cessions occurred in the 1980s in KMG and more recently, smaller but numerous ones in KAN and other areas (Figure 1, Figure 3A). Land losses are linked with high demand, but also with processes that weaken smallholders to keep a hold on their land (Figure 4A). These involve the loss of rights of ways due to the proliferation of surrounding fences and walls, and sales encouraged by the threat of municipal confiscation to favour urban promoters. Land losses are also linked with precarious livelihoods such as indebtedness, or acute needs at the end of the lean season: '[buyers] wait that people are hungry to negotiate' (FGD Zone Nord, 22.10.2019). In turn, land losses lead to further precariousness and form a reinforcing feedback loop through a land loss – poverty nexus (Figure 4B, 1).



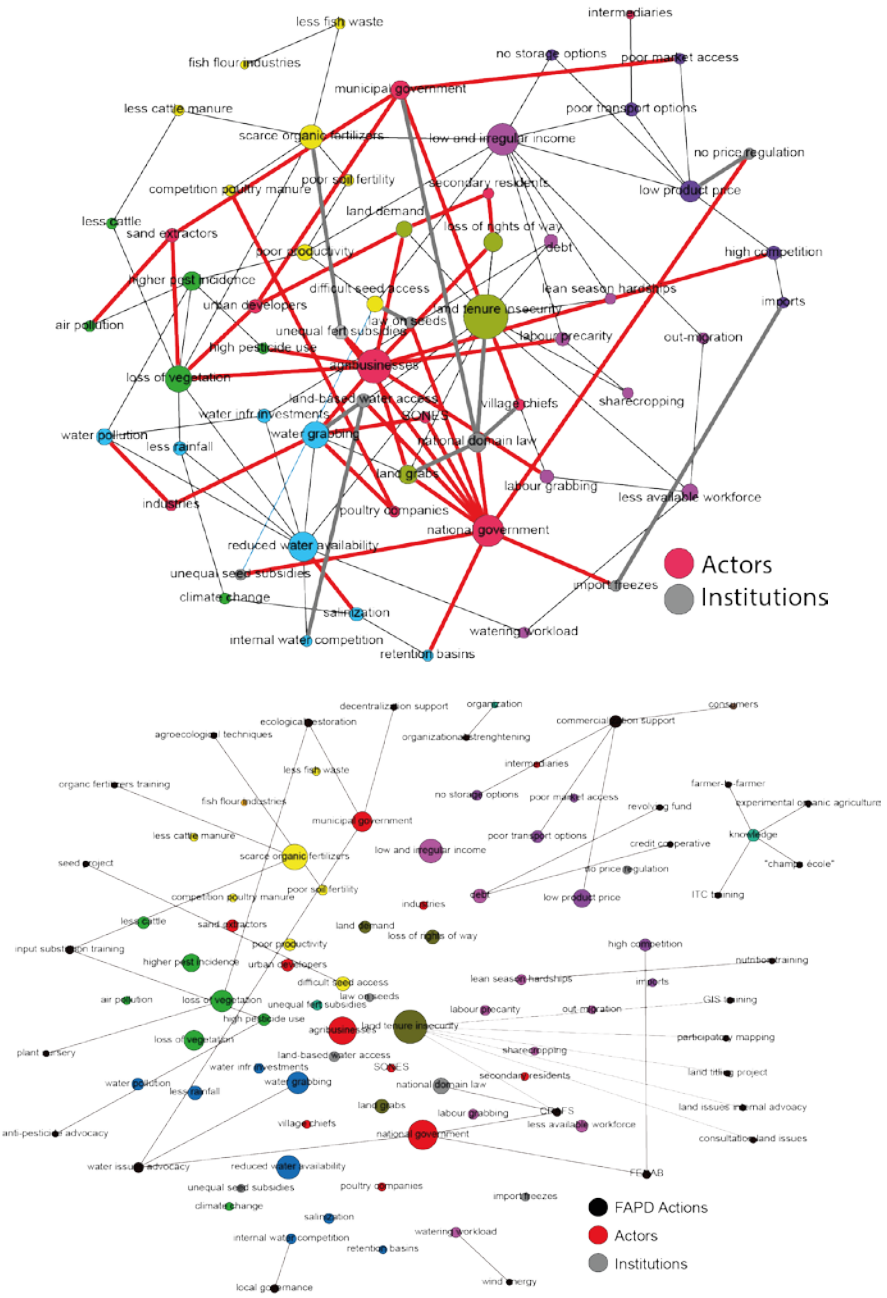


Figure 4. Network representations of smallholder farming social-ecological system (a), with identified feedback loops between system elements (b), influence of actors and institutions on system elements (c) and influence of FAPD actions (d).

Land sales are also encouraged by decreasing water availability, a major issue mentioned in all FGDs. Water table shrinking has forced farmers to dig their traditional 1-3 m waterholes called *seyyanes* into 5-15 m deep wells, and then increasing depth again by sinking PVC tubes through a semi-artisanal technique called mini-boreholes (*mini-forages*). Increased depths require increased investments in digging, pumping and drip irrigation. In KMG, farmers could do these investments and install electric pumps. A self-reinforcing water 'race to the bottom' is thus taking place, with reduced superficial water availability leads to greater water investments, uptakes, pollution and reinforced water scarcity (Figure 4B, 2). However, in other areas, many farmers could not do these

investments and reduced their cultivation areas, accumulated debts and ultimately sold their plots, thus leading to another reinforcing feedback loop through a land-water grabbing nexus (Figure 4B, 3). FGD participants also reported irregularity of water availability, which forces farmers to start watering earlier, as a participant put it: 'we need to start watering at 6 a.m., if we start at 8 a.m. there is no more water' (FGD KAN, 23.10.2019). They then need to wait for long times in their fields until water recharges (this activity is called *nassal* in Wolof), increasing workload. This leads to water-land-labour nexus feedback loops (Figure 4B, 4a and 4b): increased workload due to reduced water availability encourages land sales that leads to more water use by larger farmers and further reduced water availability.

Regarding labour issues, FGD participants mentioned the paradox that many smallholders who usually rely on family labour face a lack of workforce in their farms, but simultaneously submit their labour (mostly women and youth) to larger farmers or off-farm activities under low wages (from 2 to 3 Euro/day) and precarious conditions. This situation is favoured by high competition with seasonal workers from the rest of the country, Mali and Guinea who makes up the half or more of local workers, as confirmed in interviews with agribusinesses. It also maintains smallholders in a weak terms of trade position in upstream and downstream sides of the value chain. First, farmers have limited access to inputs that limit their productivity and in turn keeps their incomes low through an input-low productivity-poverty trap (Figure 4B, 5). This includes seeds, with only expensive and hybrid seeds with high cultivation requirements available for horticulture crops, and traditionally used cattle manure and fish waste that have become less available due to the diminishing of pastoral land and, according to the Kayar municipality, the establishment of fish flour factories for export. Second, farmers have limited market access due to lack of transport options, storage facilities and market selling space. They thus need to sell their products on-field (*bord champ*) of faster to intermediaries, which lowers their bargaining power and product prices. Dumping operated by large producers and food importers puts a further pressure on prices, and leads to a reinforcing feedback between market access and poverty (Figure 4B, 6).

Finally, FAPD Farmers observed a general degradation of the surrounding ecosystems. This includes excessive use of chemical inputs that have contaminated water, soil and surrounding vegetation (Sall, Vanclooster 2009) and has impacts on human health (Hardin 2019). Farmers also mentioned a reduction of natural vegetation due to past groundnut cultivation and large farmers cutting trees to enable mechanisation. This has led to increased pest attacks, which encourages further pesticide use and pollution, which in turn leads to more water and vegetation scarcity through a water and ecosystem degradation feedback (Figure 4B, 7). Ecosystem degradation also involves several components of the system, with reduced water and land tenure insecurity leading to loss of vegetation, loss of fertility, productivity, income, workforce and land losses, leading to a larger social-ecological degradation process (Figure 4B, 8).

Institutions, actors and appropriation processes

In each sub-system, institutions mediate between the position of farmers among

themselves and with external actors. Many of these institutions reinforce the feedback loops observed above. First, land cessions are enabled by the national legal framework on property: the 1964 law of the national domain (*Loi sur le Domaine National*) declares the State as the owner of all land. Village chiefs traditionally grant access to smallholders according to customary rules based on family ties. Nevertheless, ownership of improvements and investments on the land (*peines et soins*) is marketable and farmers can sell their investments (*cession d'impants*) or mortgage them, leading to the actual cessions of their land access rights. Such transactions approved by village chiefs can be formalized through a judgement (*deliberation*) issued by the municipality, which can be further consolidated through an official land lease (*bail*) from the State to the user. These regulations imply that first, the State can directly grant land without consulting small farmers. This is how large land portions in the KMG zone were ceded in the 1980s to private businesses, or to religious chiefs. Second, land buyers can buy cheap investments from smallholders and then consolidate their land access through deliberations and leases. Such buyers include investors based in Dakar, Touba or Europe, rich Dakar residents establishing secondary residences, poultry companies and agribusinesses. The State has further encouraged these actors through policies such as the GOANA (*Grande Offensive Agricole pour la Nourriture et l'Abondance*), a programme starting 2008 aiming at improving productivity to respond to the global food crisis (Oya, Ba 2013) and through land granted to retired functionaries.

Authorization to access groundwater is also granted by the State and control is centralized at national level. However, the State has little means to control boreholes. This leads, on the one hand, to a situation of open access which prevails when water extraction facilities increases, such as in the KMG zone. In this case, water access is de facto regulated by land access; any land 'owner' can extract water from his/her plot. This means that large land buyers can also turn into 'water grabbers', especially medium agribusinesses and secondary residents who directly pump water into the NSQ and compete with small farmers (Figure 3B). According to Diender municipality, the State also rarely denies water-extracting authorizations to industries and agribusinesses. Furthermore, since 2016 and 2019, the national government has established 11 deep boreholes to provide drinking water to the urban populations of Dakar (Figure 3B). Though not directly using the NSQ as primary water source, deep drillings affect it through underground water communication channels (interview with IPAR hydrologist, 29.10.2019).

Labour institutions also favour precarious livelihoods. Internal institutions of work include *mbeye seddo* (sharecropping: sharing of harvest in equal parts between landowner and worker), *santaane* (solidary collective work, e.g. to dig a well) and paid work that prevails even within the family, as a participant put it: 'we don't work collectively any more for parents on fields, everything is monetarized' (FGD Nord, 22.10.2019). Labour relations in the agricultural sector are mainly informal and fixed contracts with companies rare, except the poultry companies who however employ few people from the area. This situation of combined strong commodification and informality of work encourages low wages and precariousness. Smallholders are also disadvantaged

by market regulations and subsidies. National seed certification regulations favour large and foreign companies and exclude traditional farmer seeds that do not meet criteria of variety distinction, homogeneity and stability (see also (ENDA-PRONAT 2018). Subsided seeds are only available for rain fed cultures such as groundnut, sorghum and maize, as well as potato. Existing subsidized chemical fertilizers rarely reach smaller farmers and are usually captured by larger producers (IPAR 2015).

At local markets, small farmers face harsh competition with exporting agribusinesses who bring their second-choice products to local markets and intermediaries who bring vegetables from Dakar and even abroad. This has the effect to lower prices in the absence of regulations. Since 2003, the government has enacted temporary import freezes to protect the national production of onions and potatoes. Though these measures have benefited FAPD onion producers, they do not concern other crops and FAPD farmers worry about competition from low quality imports of other fruit and vegetables. Moreover, the measure has led to an overproduction of both crops leading to an excessive water pumping, chemical spread and threatening of agrobiodiversity.

Inexistent or unenforced environmental regulations contribute to ecosystem degradation. Municipal government mainly lack competencies, legitimacy and financial means to implement territorial management plans including a broader perspective of environmental sustainability. Political factionalism and corruption further lead to short-term perspectives and favour most powerful actors leading to an acceleration of environmental degradation. This includes nitrate and pesticide pollution from agriculture, plastic waste accumulation due to urbanization and the use of drip irrigation, and soil erosion and dust storms around sand extraction quarries near Kayar. Furthermore, extractive industries (zircon, ilmenite, rutile, leucoxene, phosphates and oil prospection) implemented in neighbouring municipalities and encouraged by the State have strong impacts on hydrological connectivity, groundwater pollution and depletion, deforestation and loss of vegetation cover in the whole area. Finally, foreign fishing companies using big boat infrastructures have depleted fish stocks, leading fishermen to leave their activity to dedicate to potato production or horticulture, creating additional pressure on land.

Figure 4C summarizes the main actors (in red) and the regulating institutions (in gray) involved in the FAPD smallholder social-ecological system. One can observe that agribusinesses exert a strong pressure on several components of the system including land, water, labour and markets. Furthermore, the national government appears not only as the main regulator but also as a competitor for resources through the urban water supply initiatives and preferential support to large-scale land acquisitions. Other actors, such as municipal government, secondary residents and urban developers, have effects on specific components of the system. Next section presents the actions carried out by the FAPD to support smallholders in the area.

Addressing systemic challenges: the FAPD

The FAPD started its activities by raising awareness among farmers about the dangers of pesticide use, focusing mainly on input substitution and on-site experimentations of organic agriculture. The organization then established a revolving fund to support

investment for small farmers and a credit cooperative in 2001. They also performed reforestation on salinized lands in the Tanma lake area. Figure 3C shows the chronology of the actions taken by the FAPD since its creation. For more details, see also Suppl. mat. Table 3. This primary focus on technical aspects of agroecology is visible in the discourse of the organization, who has as main objective 'the establishment of a healthy and sustainable agriculture (*Agriculture Saine et Durable ASD*) for better food security' (FAPD vision, 2019) in the region. They define agroecology as 'how to work and cultivate in a specific ecological zones while preserving the complementarity between animals, trees and microorganisms' (FAPD leader, 6.3.2019). Another leader stated that agroecology is 'an essential act, the step that can maintain land in the hands of local actors; it is a system that englobes all actions that can add value to the farm plot (*périmètre*), with reforestation, but also the practice of diversified agriculture, animal husbandry and bee keeping' (FAPD leader, 23.10.2019).

The first policy oriented actions of the organization started 2008, with the co-foundation of the National Federation of Organic Agriculture (FENAB) who is advocating for the establishment of an organic farming label at national level. These actions were mainly aiming at promoting certified organic farming. During the FGD, we observed that some individual farmers had a rather vague idea of agroecology and sometimes confused it with certified organic farming. Currently, of 1200 members of the association who are active producers, about 600 claim to be in transition towards ASD, but only 24 had organic certification involving external instances. From 2013 onwards, FAPD organic farmers are members of a cooperative that enables direct sale of about 30% of their products in Dakar elite markets. This focus on direct sale and the difficult access to certification has led FAPD leaders to assume a critical position towards organic certification, privileging participatory guarantee systems and short value chains.

Despite a relatively technical vision of agroecology, the FAPD has also developed a discourse on the defence of smallholder farming and claim to be part of the national peasant movement through their membership of the national organization defending smallholder farmers, the CNCR. In this view, they consider that the State has the obligation of helping small producers, and that land is a major heritage (*patrimoine*) for the small farmer or peasant (*paysan*). In its value statement (FAPD vision, 2019), the organization states that 'farming and animal husbandry are professions and require knowledge, know-how, organization and a personal implication', and refers to this to advocate for a better recognition of smallholder farmers in economic, political and cultural terms.

It is however only more recently that the organization has developed concrete actions to address smallholder rights issues. Actions related with land and water roughly follows the land and water appropriation process with a time lag of 3 to 5 years (Figure 3). From 2015 onwards, FAPD members attended training on GIS and land legal framework, and performed participatory mapping and field measuring. They also took part of a national advocacy group on land, the *Cadre de Refléxion et d'Action sur le Foncier au Sénégal* (CRAFS) ending up on a position document on land reform that

would encourage land registration for small-scale farmers combined with a reinforcement of local governance of commons such as forests, water and other ecosystems (CRAFS 2016). Actions on water access started 2018. The FAPD took a leading role in collaboration with the Diender municipality to oppose the SONES urban water drilling project, with the organization of public demonstrations and media interventions. They could not stop the project but they negotiated drinking water supplies for several villages in the area. Though FAPD leaders do not explicitly refer to the concept of justice in their discourse, they consider the 'abusive use of our natural resources' a major issue, especially in the case of water. They also mention the State subvention of chemical inputs instead of organic ones as unjust.

FAPD leaders also see agroecology as a social movement; they explicitly mention that agroecology has a federative power among farmer organizations in the country and gives them visibility to the national government. However up to now, the organisation as mainly worked as a technical assessor or an extension agency rather than a political movement supported by rural grassroots and rural authorities. Most political work has focused on convincing national authorities to adopt principle of agroecology in their agricultural policies. As an FAPD leader states: 'what has changed is that now the national authorities are taking agroecology into account'. Agroecology is however also a strategy to access external support for both national agencies as well as for farmers' organisations, which includes some limitations in terms of political and financial anchorage. The Dakar-based NGO ENDA Pronat has supported the organization since its creation and when they stopped in 2010, the FAPD also stopped its activities. After 2012, they managed to raise funding from diverse sources, in particular the Swiss NGO HEKS, who was instrumental in supporting the project on land tenure security and in which ecological farming and land advocacy were closely tied (FAPD activity report 2017). The FAPD also managed to get funds from the state for an input substitution project and from North American research organizations.

These statements confirm the importance of agroecology and related notions to establish a systemic view of farming and enabling the coordination of diverse actions with increased societal and political scope. Figure 4D shows how these different actions are tied to specific system elements and their relevant actors and institutions. Three clusters are visible, first the actions that aim at influencing ecological and productive components, focusing on agroecological and input substitution training. A second cluster includes commercialization support and a third one land issues support. Other actions appear relatively isolated in their connection to subsystems. Furthermore, connection with key actors, such as national government, occurs mainly through national platforms such as FENAB and CRAFS. Direct ties with governance bodies include the municipal government of Diender, but there are no direct ties with actors such as agribusinesses, secondary residents or industries.

Discussion

Our findings show the strong social-ecological nexuses that matter for smallholder farmers, including the land-water nexus, but also key processes that link land and water

with labour and poverty issues, which in turn also affect other components of the system, in particular the position of actors within value chains. With such linkages, potential shocks and changing conditions such as a drought but also a large land lease can trigger feedback loops that further weaken the position of smallholders. Some assets such as groundwater availability have already been undermined by changing climatic conditions for a long time (Aguiar *et al.* 2010). However, many more recent pressures on identified processes are clearly social and exacerbate these changing conditions.

Agribusinesses exert a strong pressure on several assets such as land, water, workforce, and input and output markets. Nevertheless, many other actors play a role, including secondary residents, urban developers, extraction industries and urban consumers of food and drinking water. Thus, one cannot identify a single 'grabber' but rather a combination of several actors who exert simultaneous pressure on smallholder assets and more broadly, their social-ecological position, namely the positioning of individuals and social groups within human and non-human networks and spaces of action (Charli-Joseph et al. 2018). Most of these actors are actively encouraged by the State, either with direct action or via the enactment of regulations that favour them and leave smallholders with little power. These findings support a political economic interpretation of the observed social-ecological processes, by which some actors accumulate assets at the expense of others through institutions actively supported by the State (Moore 2015).

The transformative potential of collective action centred around the practice and discourse of agroecology appears therefore crucial. We observe that agroecology has helped farmers and their organisations to better identify issues from a systemic perspective and develop a complex positioning. The technical and capacity building phase that has consolidated the work of farmers' organization was instrumental in building this thinking. More recent engagements of the organization in land and water access issues is also consistent with the expanding scope of the agroecological movement found elsewhere (Altieri, Toledo 2011; Gliessman 2016). However, the organization faces several limitations. First, focusing on systemic and diffuse dispossession process is challenging in terms of complexity and resources to be invested on several fronts. Second, unlike other peasant organizations such as in Latin America (Bottazzi, Rist 2012), the FAPD does not have a financial autonomy generated through the contribution of his members or the ownership of productive assets. Third, FAPD can use agroecology as a strategic positioning to capture support from external actors and advocacy coalitions, while many Senegalese peasant movements do not share this focus. This position can enhance the organization's visibility and ability to build ties with decision makers, but also create dependency and favour specific issues, such as input substitution or land rights, to the expense of others, such as labour relations.

Our observed multitude of concomitant and interrelated factors of social-ecological degradation further expand Haller's (2019) idea of resilience grabbing. First, the land-water nexus needs to be expanded to consider other feedback loops including unfair labour conditions, unregulated value chains and broader ecosystems degradations.

For example, the loss of resilience capacity of small farms increases cheap labour availability and serves the interest of larger farmers. Second, assets are key to resilience and are likely to support other resilience components such as self-organization and capacity for learning. These assets – or commons, in a broad sense - need to be understood in dynamic and relative terms also including non-material assets such as labour rights or producer-to-consumer networks. Third, resilience from a power perspective can be apprehended as a power-related position within social and ecological spaces (Charli-Joseph et al. 2018). Resilience grabbing can then be conceptualized as a weakening of this position that results from the influence of specific actors that are not necessarily related. In this context, climate change, land degradation and environmental contaminations becomes more severe threats for farmers suffering from resilience grabbing.

Our findings also expand the concept of resilience justice (Arnold 2018) that builds on the main idea that social groups do not have equal rights and opportunities in front of environmental threats as they suffer from an unequal distribution of vulnerability, assets and capacity to adapt. The difference also clearly appears in terms of agency to mobilise access to information and resources for collective action. To capture such agency in both social and ecological terms, we have argued that the notion of resilience justice needs to be expanded in both vertical and horizontal terms. We can now precise its implications. In vertical terms, it means adding up concerns of distributive justice which address how assets that are key to resilience are distributed, with procedural justice, namely the ability for groups and individuals to meaningfully participate in decision-making, and with recognition justice, namely the respect for different views, culture and ways of framing problems (Schlosberg 2013). These dimensions are visible in our case study, with the farmer organization making distributive claims to natural resources but also trying to influence institutions of land access and claiming for better recognition of 'peasant farming' as a professional activity.

In horizontal terms, this implies to look at justice issues in relation with interlinked social-ecological assets and processes integrating land, water, ecosystems but also labour relationships and positions in value chains. This can be particularly challenging because first, the involved actors that make justice claims (the subjects of justice in the sense of Sikor *et al.* 2014) and the responsibilities can be difficult to identify in relation with such complex nexuses. Second, the very framing of social-ecological nexuses varies according to actors and interests (Boillat *et al.* 2020). A knowledge co-production process as done in this study can help to identify system linkages through bottom-up processes, diffuse responsibilities and potentially delayed impacts through social-ecological nexuses (Pascual *et al.* 2017). Such framing however challenges legal frameworks and liability systems that work through nested territories of governance and build on direct cause-effect relationships (Arnold, Gunderson 2013) rather than multiple chains of causalities. One would therefore need to switch from liability approaches to social connection models and risk distribution assessments (Pellizzoni, Ylönen 2008), and move away from strict production-based responsibility to combine consumer and producer responsibility (Marques *et al.* 2012).

By focusing on one farmer union as a starting point, we have intentionally overlooked the question of identifying subjects of justice and the need for a broader examination of mechanisms through which victims of environmental burdens are identified (Ureta *et al.* 2019). Internal power relationships and the position of more marginalized groups such as land tenants, young people and some women's have not been addressed. We thus suggest to perform more research taking either different actors and sub-groups and their systemic views as a starting point, or focus on institutions to identify subjects of justice. This could be done following the all-subjected principle that considers all those who are jointly subject to a given governance structure have moral standing as subjects of justice (Fraser 2010), or identifying the polycentric governance spaces (Oberlack *et al.* 2018) in a broad sense that might regulate and affect the elements of the examined system.

Our last element of discussion concerns the potential of agroecology as a transformative pathway to resilience justice. Farmer organizations do integrate system thinking, technical knowledge and justice claims, but this expansion is relatively recent and limited in reach in the examined case. An overall focus on technical and capacity building aspects of agroecology can obscure the power relations at work, as it is the case with most resilience approaches (Fainstein 2015). The relative dependence of Senegalese farmer organizations on external support (Hrabanski 2010) encourages limitations in scope. Focusing on agroecology thus does not guarantee to follow a transformative and emancipatory pathway. Agroecology as a social movement (Wezel *et al.* 2009) has yet to integrate more explicit elements on collective decision-making and political processes (de Molina 2013). Based on our findings, we argue that on the one hand, the agroecology agenda might get 'stuck' when key questions of social justice are not addressed. On the other hand, agroecology also needs to address more specifically the role of labour relationships to activate its transformative potential (Bottazzi 2019).

Conclusion

We have assessed the importance of social-ecological and systemic ties in the diffuse dispossession process that undermine the resilience of smallholders in a very dynamic coastal region of sub-Saharan Africa. The notion of resilience justice helps reconstituting the chain of direct and indirect causes of social-ecological degradation in relation with the network of stakeholders agencies. The holistic perspective offered by agroecology can potentially address issues of resilience justice. As a scientific approach, agroecology is fundamentally and systematically open to the complexity of agro-socio-ecological nexuses and to non-academic knowledge production. As a social movement it includes notions of justice and equity as basic features of sustainability. As a set of practices it is turned toward stakeholders' agency and adapted solutions and technologies to favour most vulnerable land users' autonomy and dignity. Our case study support the idea that the agroecological movement is at a very early stage in sub-Saharan Africa compared to elsewhere (Altieri, Toledo 2011). However, our case also suggests that the movement has the potential to identify and address many of the interrelated challenges that the most vulnerable rural and peri-urban populations are facing: a quick and serious reduction of

social-ecological resilience related to both global environmental threats and a combination of irregularities and inequities in resources access, distribution and regulation. The movement has been able to build a systemic understanding of those threats and has been able to build strategic alliances with national and international agencies. However, it is still missing a stronger anchorage in its own grassroots including farm workers and other rural stakeholders defending food sovereignty and sustainable food systems. Such a reinforcement could considerably increase its political and financial legitimacy and, in consequence, its resilience.

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